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ABSTRACT

The cognitive approach to education and instruction is discussed, with a focus upon achievement test question processing. A model of multiple-choice processing is discussed and used to develop a proposed model of recall processing. Each model is tested by the means of investigating the use of retrieval cues in processing each type of question. The reading comprehension of twenty male and female undergraduates was measured with a multiple-choice test, and that of another twenty subjects was measured with a recall test. The questions in each test were designed to test the importance of cue location and availability in achievement test question processing. The results indicated that for multiple-choice tests, the optimal strategy may be one of processing the whole item, stem and alternatives, especially if specific semantic cues appeared in the alternatives. These results support the chosen model of multiple-choice processing. The analysis of the recall responses indicated that the processing can occur successfully with general context cues only: however, performance is better with the use of general context and specific class cues. Such an interpretation was used to modify the suggested model of recall processing. (Author)

Processing Multiple-Choice and Recall Test Questions

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Abstract

The cognitive approach to education and instruction is discussed, with a focus upon achievement test question processing. A model of multiple-choice processing is discussed and used to develop a proposed model of recall processing. Each model is tested by the means of investigating the use of retrieval cues in processing each type of question. The reading comprehension of twenty male and female undergraduates was measured with a multiple-choice test, and that of another twenty subjects was measured with a recall test. The questions in each test were designed to test the importance of cue location and availability in achievement test question processing. The results indicated that for multiple-choice tests, the optimal strategy may be one of processing the whole item, stem and alternatives, especially if specific semantic cues appeared in the alternatives. These results support the chosen model of multiple-choice processing. The analysis of the recall responses indicated that the processing can occur successfully with general context cues only; however, performance is better with the use of general context and specific class cues. Such an interpretation was used to modify the suggested model of recall processing.

The current trend in educational/instructional research focuses upon the internal processing by the learner. Wittrock's (1978) cognitive perspective prompts the researchers to pay special attention to individual differences between and within learners. Anderson's use of schemata as internal representations of information directs attention inward toward some internal processes of encoding (Anderson, R., Spiro, R., & Anderson, M., 1978) as does Lockhart, Craik, and Jacoby's (1976) elaborations upon the depth of processing notion. Sternberg (1978, 1979) uses an information processing approach to postulate seven basic mental abilities which may account for most of human problem-solving. This trend towards an awareness of the necessity of methods and conceptualizations which attempt to understand and measure the internal, within-the-learner, processes is a welcome step towards better understanding the learning process. However, this attention to learner-oriented processes and variables must be balanced by some equal understanding of task-oriented variables. Although the evidence for trait-treatment interactions is confusing and ambiguous, it can be generally assumed that such interactions do exist in some situations. These situations probably exist in many everyday tasks, and as such, should be investigated if psychology is to reach a full understanding of learning. One such situation, or more correctly, set of situations, is schooling. In schooling, the situation variables include lecture, note-taking, testing, text construction, and many others too numerous to list.

Even these situations are complex enough that much of the results of research done to date within the classroom is unclear at best. Either of two solutions could be attempted. The situations could be disected into even smaller, but easier to study, units; and these, in turn, recombined into a total picture which is hopefully not too far removed from the situation of initial interest. Second, some methodology to investigate large, complex phenomena could be developed and the risk of changing the situation beyond any generalizations would be avoided. Unfortunately, the development of such encompassing methodologies is too slow to quench most researchers' thirst for understanding and we are left with the first solution, that of breaking large phenomena into smaller phenomena.

Consequently, this study is one of investigating a portion of the task of achievement test construction for the classroom use. Specifically, that portion of test construction under investigation is the use and placement of retrieval cues in multiple-choice and recall test questions. The reasoning for choosing cue placement and utilization as the voci of study is simple. Cues play an important role on the retrieval of information. "What people retrieve from their cognitive representation of information from a passage depends, of course, not only on what is retained, but also upon the nature of the cues provided," (McConkie, 1978, p. 35). In the typical classroom, much of the evaluation and feedback related to both the teacher and student performances is derived from the student performance on achievement tests. Classroom achievement tests typically take the form of multiple-choice or free recall questions. In order to understand how students process these different types of questions, a model of processing must be suggested and tested. When testing such a model, ~~the~~ importance of retrieval cue location and availability becomes important.

Test Question Processing

From the above introduction, it is apparent that before any investigation of the effects of cue placement and availability can be attempted, a model of question processing should be stated. It is most likely true that there are differences in the processing of multiple-choice and recall questions. Basically, "the free-recall task typically provides the least cue information, and hence it provides the lowest recall levels for specific information from the passage (Schulster & Crouse, 1972)" (McConkie, 1978). For this reason, the processing of the two types of questions were tested separately and shall be discussed separately.

Multiple-Choice Processing

The recent model of multiple-choice processing developed by Phye (1979) is the model adopted for this study. According to this model, depicted in Figure One, students first read the stem and alternatives of a single item. From this reading, students search for grammatical or syntactic cues for an answer. If these cues are present and adequate, that answer is chosen and the student proceeds to the next item. If there are no such shallow cues available, the student proceeds with a context search. The context of the item is the general area about which the inquiry is made. For example, the context of a question in military science could be basic tank warfare strategies. At this stage of processing, one of three conditions may be present. First, if there is no familiar context present at all, the student must guess. On the opposite extreme, the context alone may be sufficient for the student to form a specific memory representation of the answer. In this case, the student immediately answers the question and proceeds to the next item. Theoretically, the most common condition is that the context cues provide only enough information for the student to continue his/her processing of that item, searching the familiar contexts for class cues.

Insert Figure One About Here

The class cues are specific examples or episodes within the context. In our military science example, the class cue may be Patton's tank strategy during his invasion of Sicily. If the class cues elicit a familiar representation of an answer, the alternatives are narrowed; if not, the student responds on the basis of the context cues only. The narrowing of alternatives would leave either one alternative as the specific memory representation of the answer, or a number of alternatives from which the student responds on the basis of class cues.

The specific memory representation could operate by some mechanism similar to schema. According to Andersen, Spiro, & Andersen (1978, p. 434), "a schema will contain slots into which some specific information described in a message will fit . . . Information that fits the superordinate schema is more likely to be learned and remembered, perhaps precisely because there is a niche for it." A specific memory representation could possibly be constructed from such schemata or some such existing knowledge set.

The author would like to call the processing strategy depicted in the model developed by Phye a selection strategy, as the student selects from all of the alternatives and cues in forming his/her specific memory representation. However, there is another possible strategy, see Figure Two, that the present study also investigates. This strategy involves reading the stem only and immediately engaging in a context search. If the contextual cues are sufficient to generate a specific memory representation of the answer, such a representation is matched to an alternative and the next item is attempted. If the context cues are not sufficient, the student guesses. If these cues only partially provide an answer, the student proceeds to search via the selection strategy method.

To distinguish between the selection strategy and the one described in the previous paragraph, and because the students process the broad context cues first, the author calls this new strategy a reception strategy. Thus there are two proposed processes for multiple-choice processing which differ mostly by what type of cues are utilized. The selection strategy uses all of the cues, while the reception strategy uses only the context cues. The selection strategy is the safest as this strategy considers the most information by utilizing the class cues. The reception strategy loses this effectiveness, but gains in potential efficiency, as less time may be needed to answer the question.

Insert Figure Two About Here

Recall Processing

The initial recall processing model, proposed by the author, is highly similar to the reception strategy extrapolated from the multiple-choice processing model developed by Phye (1979). As with the reception strategy, no class cues are utilized, only the broad context cues. The major difference between this recall processing model and the reception model is that, unlike the reception model, the students cannot initiate a search of the alternatives for cues because there are no alternatives provided. In Figure Two, then, the dashed and slashed lines represent the reception strategy for multiple-choice processing, while only the slashed lines represent the proposed recall processing model.

Cue Location and Type

From the models of question processing described in this study, it is possible to describe two types of cues, the context and class cues. The meanings of the terms context and class cues can be defined in terms of their inclusiveness-exclusiveness, superordinate-subordinate relationship within the general knowledge set of the area of inquiry. Context cues are the more inclusive and would serve to elicit the more superordinate cognitive representation or schema into which a given or constructed answer may fit. Class cues, however, elicit the more specific, subordinate representation within an already elicited schema.

In order to approximate the possible types of multiple-choice and recall questions used in the classroom, as defined by cue location, four types of multiple-choice and two recall questions can be developed.

Multiple-choice. Multiple-choice questions are composed of two portions, a stem and alternatives. Experience suggests, that in the typical classroom use, the stem will contain some context cues and may or may not contain class cues. The alternatives, on the other hand, may or may not contain class cues and rarely contain context cues. Thus, four question types should represent most of the multiple-choice questions used in the classroom. All of the four would have context cues in the stem. Question Type One (Q1) contains stems with class as well as context cues, and alternatives with only class cues. These represent questions which could be answered on the basis of the stem alone and are the most prevalent in multiple-choice tests. Question Type Two (Q2) also contains both cue types in the stem, but no appropriate class cues in the alternatives. In other words, due to faulty encoding or retrieval, or a poorly stated item, the information is not recoverable to the specificity required by the item. Question Type Three (Q3) contains no appropriate class cues in the stem, however, they appear in the alternatives. These represent questions in which the specific answer is elicited only by processing the alternatives as well as the stem. Question Type Four (Q4) contains only context cues in the stem. These represent those questions for which the students must ultimately guess.

Recall Only two types of recall questions are defined by cue location. As with multiple-choice questions, both types contain context cues, however, Question Type One (Q1) also contains appropriate class cues.

EXPERIMENT 1

The study was conducted in two parts. The first experiment was an investigation of multiple-choice processing based upon the model proposed by Phye (1979).

Method

Subjects

The subjects were twenty male and female undergraduates from a large midwestern university. Ten of the subjects composed the experimental group, while the remaining ten composed the no-treatment-control.

Test

The test was a forty item multiple-choice test. There were ten questions designed for each of the four aforementioned multiple-choice question types, arranged in random order. The test was based upon an 'anthropological study' of a fictional African tribe called the Himoets (Myrow & Andersen, 1972). Included in the Myrow & Andersen study was a report about another 'tribe' called the Gruanda. These two reports paralleled each other in general context, while they differed in the specifics within these contexts. In order to have the questions on the test balanced with respect to the availability of some class cues in the stem, class cues based upon the Gruanda text were included in these stems which lacked appropriate, Himoet, class cues, ie., Q3 and Q4. These questions did not contain any informative class cues, but did contain class cues of a possibly mis-informative nature.

Procedure

Prior to reading the passage, the subjects were administered the test as a pretest. During the experimental sessions, the subjects read the passage as it was presented on a memory drum. Immediately after reading the passage, the experimental group was administered the posttest. The control group did not read the passage and was administered the posttest immediately after the pretest. The results were analyzed by correct response and error analyses.

Design

The design was a 2 (experimental/control) x 4 (question type) x 2 (trial) split plot with a no-treatment-control.

Results

The error analysis for the multiple-choice data was a 2 (experimental/control) x 4 (question type) MANOVA. The only significant result $F(3,72) = 4.15$, $p<.01$, was for new errors. The Tukey's comparison of means indicated that the mean proportions of the experimental condition Q2, 0.40 and Q3, 0.13 formed the only significant comparison. New errors occur when the subject has a correct response on the pretest item, but misses that item on the posttest.

The correct response analysis for the multiple-choice data was a 2 (experimental/control) x 4 (question type) x 2 (trial) ANOVA. The experimental/control main effect (excon) was significant $F(1,18) = 7.66$, $p<.02$, with means of 3.74 and 2.75 for the experimental and control groups, respectively. The interaction of excon and question type was also significant $F(3,54) = 5.23$, $p<.004$. The main effect of trial was also significant $F(1,18) = 8.97$, $p<.008$, as well as its interaction with question type $F(3,54) = 5.86$, $p<.002$. The means of the main effect of trial were 2.68 and 3.81 for the pre- and posttests, respectively. Finally, the interaction of excon by question type by trial was significant $F(3,54) = 6.76$, $p<.0009$. The means for this three-way interaction can be found in Table One.

Insert Table One About Here

Discussion

Error Analysis

The error analysis indicated that questions which contained class cues in the alternatives only, as opposed to class cues in the stem only, elicited fewer new errors. New errors occur when feedback about the pretest performance was not confirmatory, for whatever reason, and the subjects then miss items which were previously correct. It appears that when class cues appear in the alternatives, the confirming nature of feedback may be facilitated.

Cotrect Response Analysis

Consider the manipulation of cue availability and location. It is reasonable to assume that if the amount of cues available, rather than cue location, is the more important to performance, a specific hierarchy of question types would become apparent. That is, if cue availability is the more important, the Q1 performance would be the best as it contains the most cues. Second in importance to performance would be the Q2 and Q3 types. Finally, Q4 performance would be the worst. However, if cue location were the more important, a different hierarchy would be expected. The nature of this hierarchy would depend upon the importance of each type of cue at each location.

Figure Three illustrates graphically the correct response analysis of the multiple-choice data for the highest order interaction. The first graph depicts the experimental group, and the second, the control. There are no significant differences between the experimental pretest (T1) and either of the control scores for any question type. There is also no significant difference between Q1 and Q3 performance. This may indicate that the amount of cue availability is not as important as the location of the cues in the question. Further support for this comes from the finding that Q2 performance does not differ from the Q4 performance, as illustrated in Figure Three. Apparently, cues are most facilitative of optimal performance when they appear in the alternatives portion of the item.

Insert Figure Three About Here

There is one more similarity between the Q1 and Q3 questions which may help account for these results. Although any specific content cues in the Q3 stems were from a passage unknown to the subjects, the general context did apply to the Himoet text. Thus, even with specific cues which could mis-direct, the subjects are able to respond correctly on the basis of the general context in the stem and the specific class cues in the alternatives. This fits the model of multiple-choice processing proposed by Phye (1979). The finding that those questions which have the proper class cues in the alternatives elicit better performance than those which don't suggests that although the dashed line alternative in Figure Two is intuitively possible, most subjects rely upon the class cues in the alternatives, as well as a context search. If a context search were generally enough, Q2 performance should have been similar to that of Q1 and Q3. Clearly, as seen in Figure Three, it was not. Apparently, the selection strategy is the optimal strategy for multiple-choice processing.

EXPERIMENT 2

The second experiment was based upon the model of recall question processing proposed in this paper.

Method

Subjects

The subjects were twenty male and female undergraduates from a large midwestern university. Ten of the subjects composed the experimental group, while the remaining ten composed the no-treatment-control. The subjects were not the same subjects who took part in Experiment One.

Test

The test consisted of forty short-answer items with each item based upon a rewording of a multiple-choice item. Thus, twenty questions contained both context and class cues related to the Himoot text, while the remaining twenty questions contained related context cues with possibly misleading class cues.

Procedure

The procedure was identical to that used in Experiment One, with the exception of using the recall test instead of the multiple-choice test.

Design

The design was a 2 (experimental/control) x 2 (question type) x 2 (trial) split plot with a no-treatment-control.

Results

The error analysis for the recall data was a 2 (experimental/control) x 2 (question type) MANOVA. For perseverative errors, those which were the same incorrect response on both tests, the excon main effect was significant $F(1,36) = 8.19$, $p < .008$, with mean proportions of 0.17 and 0.40 for the experimental and control groups, respectively. For different errors, those in which both test items were incorrect, but a different incorrect alternative was chosen on each test, the excon main effect was again significant $F(1,36) = 6.01$, $p < .02$, with mean proportions of 0.91 and 0.67 for the experimental and control groups, respectively.

The correct response analysis for the recall data was a 2 (experimental/control) x 2 (question type) x 2 (trial) ANOVA. The main effect for excon was significant $F(1,18) = 16.99$, $p < .001$, the main effect for question type was significant $F(1,18) = 20.92$, $p < .001$, and their interaction was significant $F(1,18) = 7.53$, $p < .02$. The main effect for trial was also significant $F(1,18) = 23.11$, $p < .001$, as was its interaction with excon $F(1,18) = 29.31$, $p < .0002$. Finally, the three-way interaction of excon by question type by trial was significant $F(1,18) = 6.30$, $p < .03$. The means for this three-way interaction can be found in Table Two.

Insert Table Two About Here

Discussion

Error Analysis

The control group committed more perseverative errors than did the experimental group, while the experimental group committed more different errors. It appears that subjects, having read the text only once, knew when they were incorrect on the pretest, but did not know the correct answer. This could be a reflection of the difficulty of the test and/or the uniqueness of the text. When no text was provided, the subjects adopted a strategy of consistency in responding by use of the same choices used on the pretest.

Correct Response Analysis

Figure Four illustrates graphically the results of the three-way interaction for the recall data. The first graph is the experimental group results, and the second, the control results. There was no significant difference between any experimental pretest scores and any control scores. Although both the Q1 and Q2 performance improved significantly on the posttest, the Q1 performance was significantly better than the Q2 perfotmance.

Insert Figure Four About Here

If the previous assertion that the recall strategy was most similar to the reception strategy was correct, one would not expect any differences in performance between the two question types. That is, since the reception strategy relies upon the context only, and both question types contained appropriate context cues, the performance of each question type should be the same. Clearly, from Figure Four, the performance on each type of question was not the same. Apparently, recall questions are answerable by use of the general context cues alone, but informative specific cues provide for optimal performance. By applying these results to the model of multiple-choice processing developed by Phye (1979), the resulting model of recall processing is similar to that depicted in Figure Five. Notice that rather than responding solely on the basis of context cues, the subject may also respond on the basis of class cues.

Insert Figure Five About Here

Conclusion

The finding that the error analyses did not provide much in the way of significant results is not very surprising. The form of error analysis used in this study, it has been suggested, is most sensitive to individual differences in processing (Bender & Phye, 1979, and Phye, 1979). The manipulations in this experiment could have been so gross that any effect due to individual differences in processing could be over-shadowed. Such a line of reasoning would suggest that cue availability, one of the main manipulations of this study, is of overriding importance in test item construction.

The two models of processing finally supported by the results of this study are similar to the processing involved in the model of recall processing proposed by Lockhart, Craik, & Jacoby (1976). The processing involved with the current study is most closely related to the processing within a specific level, i.e., semantic processing. It appears that within the level of semantic processing, the level of processing may vary according to the quality of the retrieval cues available. General cues provide enough information to partially answer some recall questions, while specific cues provide for optimal answers.

As can be seen by comparing Phye's model of multiple-choice processing, Figure One, with the final model of recall processing, Figure Five, this concept of different levels of semantic processing within more general levels; specifically, that different levels of semantic processing could occur due to the type of cues available; applies to both multiple-choice and recall questions. This could be taken to be analogous to the assertion by Lockhart et al. (1976) that recognition and recall both involve some form of reconstruction. One form, that associated with recall, is based upon the experimenter-provided information. The other, that associated with recognition, i.e., multiple-choice questions, is based upon cue location in the item. However, one difference between this analysis and that of Lockhart et al. (1976) is that recognition processing in the Lockhart et al. model is based upon cue similarity to some memory trace, not cue location. This difference could be due to a difference between the recognition processing tasks used by Lockhart et al. and the recognition processing associated with multiple-choice questions.

Although the results of this study appear to closely approximate current models of processing, there would be problems. The major problem could be in accepting that there are definite differences in the processing of the question types and that if they do exist, this study actually reflected those differences. It is possible that the results are an artifact of the test taking strategy adopted by most subjects. That is, most subjects may have adopted a specific strategy which favored Q1 and Q3 multiple-choice and/or Q1 recall questions. To control for such a strategy adoption, a possible design would be to block the subjects across question types. Each group of subjects would then be given a test composed of only one question type. That is, the question type would become a between groups rather than a within groups variable.

In conclusion, this study was an attempt to answer questions concerning the placement and use of retrieval cues in processing. It is suggested that retrieval cues are necessary; however, the amount of cues available may not be as important as the quality or location. The use of the cues also depends upon the type of question asked, be they recall or multiple-choice. In recall processing, optimal performance relies upon specific cues, rather than the general context cues. In multiple-choice questions, the specific cues are most facilitative of processing if they appear in the alternatives, as opposed to the stem, as long as the stem provides some general context cues. These results were found to fit the model of multiple-choice processing developed by Phye (1979). They also suggest a model of recall processing derived from the Phye model.

Reference Notes

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Table One

EXCON	QTYPE	TRIAL	N	MEAN
E	1	1	10	2.70
E	1	2	10	5.70
E	2	1	10	3.50
E	2	2	10	2.80
E	3	1	10	2.20
E	3	2	10	5.50
E	4	1	10	3.60
E	4	2	10	3.90
C	1	1	10	1.80
C	1	2	10	2.70
C	2	1	10	3.40
C	2	2	10	4.00
C	3	1	10	2.40
C	3	2	10	2.90
C	4	1	10	1.80
C	4	2	10	3.00

Table Two

EXCON	QTYPE	TRIAL	N	MEAN
E	1	1	10	2.30
E	1	2	10	9.20
E	2	1	10	0.70
E	2	2	10	5.60
C	1	1	10	2.50
C	1	2	10	1.80
C	2	1	10	1.50
C	2	2	10	1.50

Figure Captions

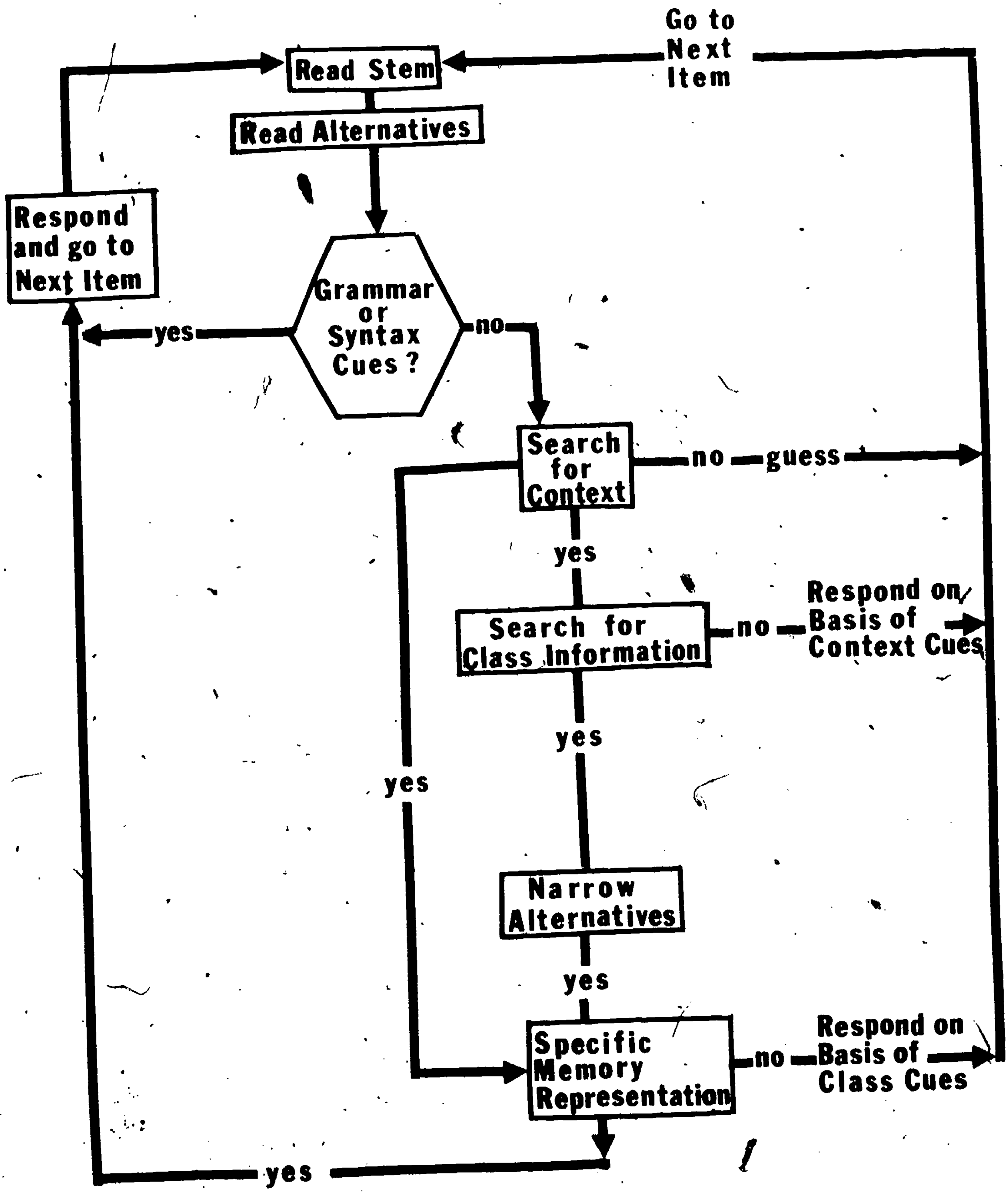
Figure 1. Processing Model of Multiple-Choice Test Performance (Phye, in press).

Figure 2. Selection and Reception Processing Model of Multiple-Choice and Recall Test Performance.

Figure 3. Correct responses at trials for all multiple-choice question types in experimental and control groups.

Figure 4. Correct responses at trials for all recall question types in experimental and control groups.

Figure 5. Final Processing Model of Recall Test Performance.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Read Stem
Read Alternatives
Respond and go to Next Item
Grammar or Syntax Cues ?
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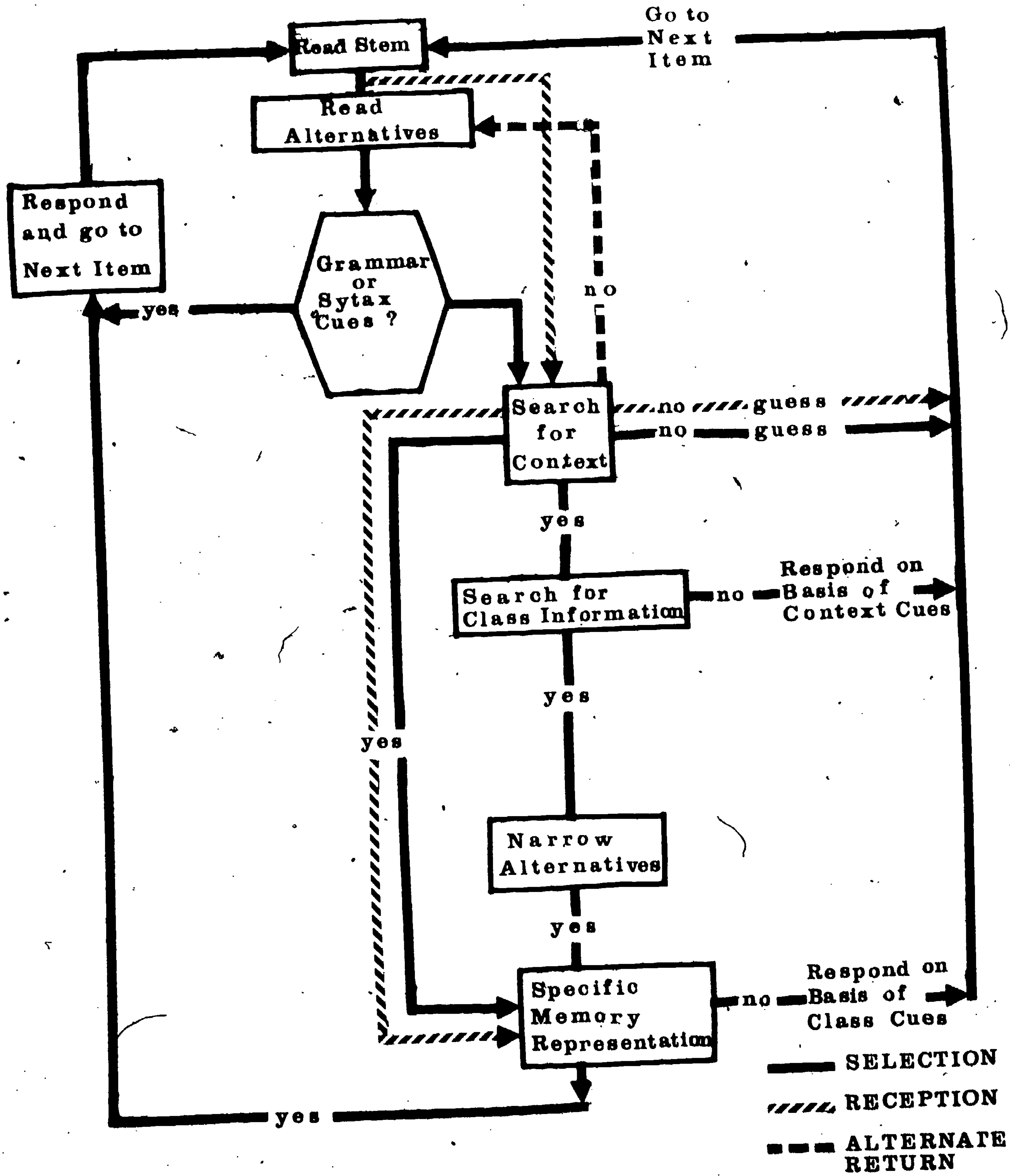
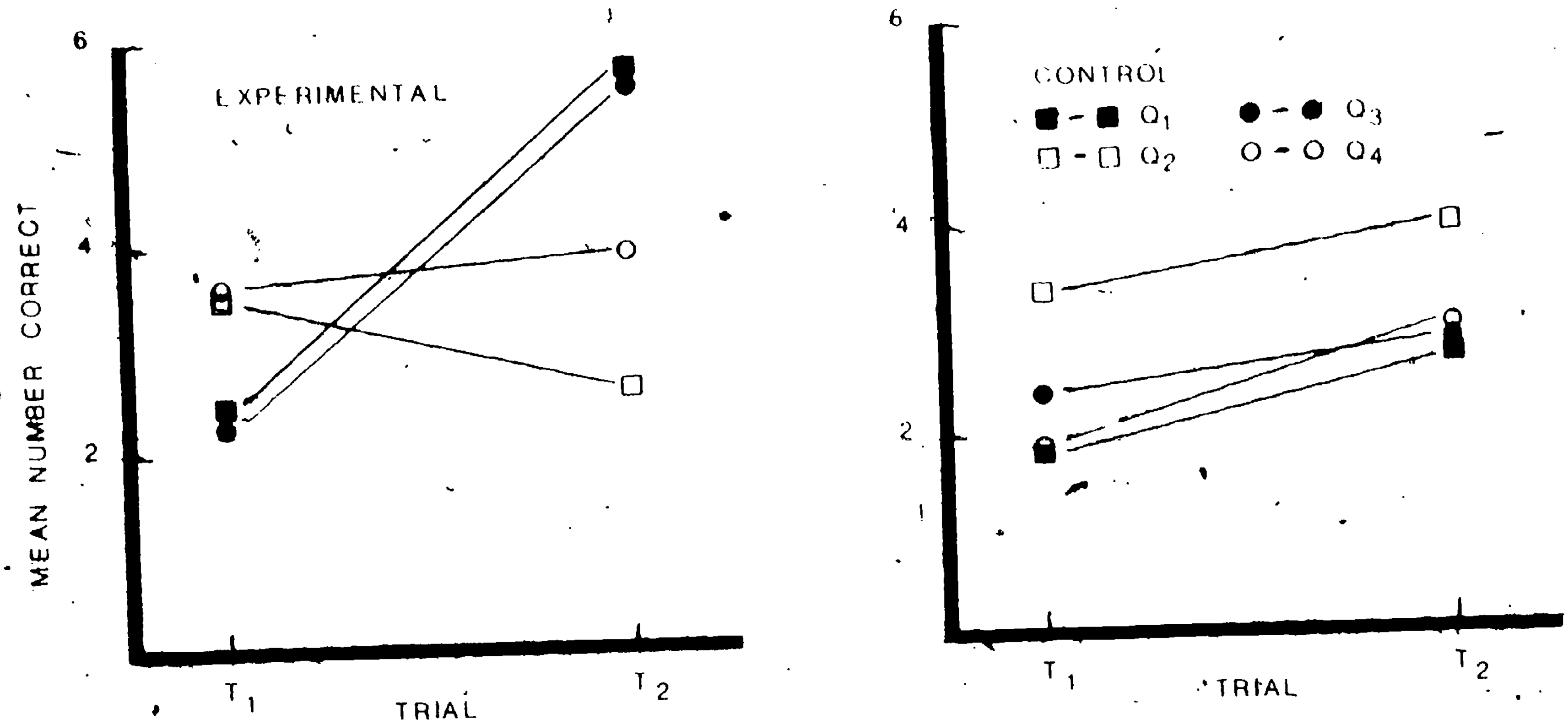
no
Search for Context
no
guess
yes
Search for Class Information
no
Respond on Basis of Context Cues
yes
yes
Narrow Alternatives
yes
Specific Memory Representation
no
Respond on Basis of Class Cues
yes


Read Stem
Go to Next Item
Read Alternatives
Respond and go to Next Item
Grammar or Sytax Cues ?
yes
no
Search for Context
no guess
no guess
yes
Search for Class Information
no
Respond on Basis of Context Cues
yes
yes
Narrow Alternatives
yes
Specific Memory Representation
no
Respond on Basis of Class Cues
yes
SELECTION
RECEPTION
ALTERNATE RETURN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4
2
EXPERIMENTAL
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T2
TRIAL
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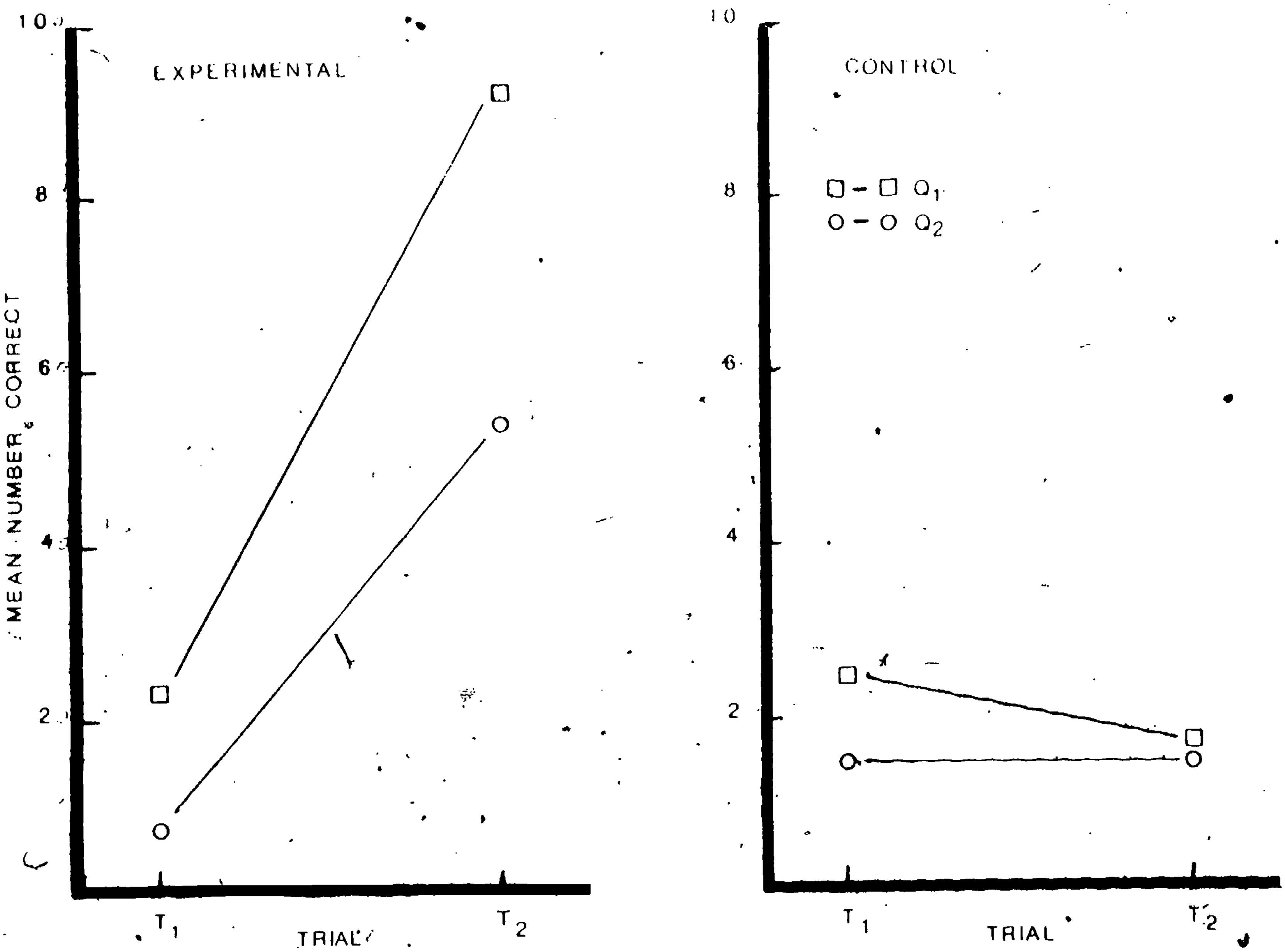
4
2
CONTROL
Q1
Q2
Q3
Q4
T1
T2
TRIAL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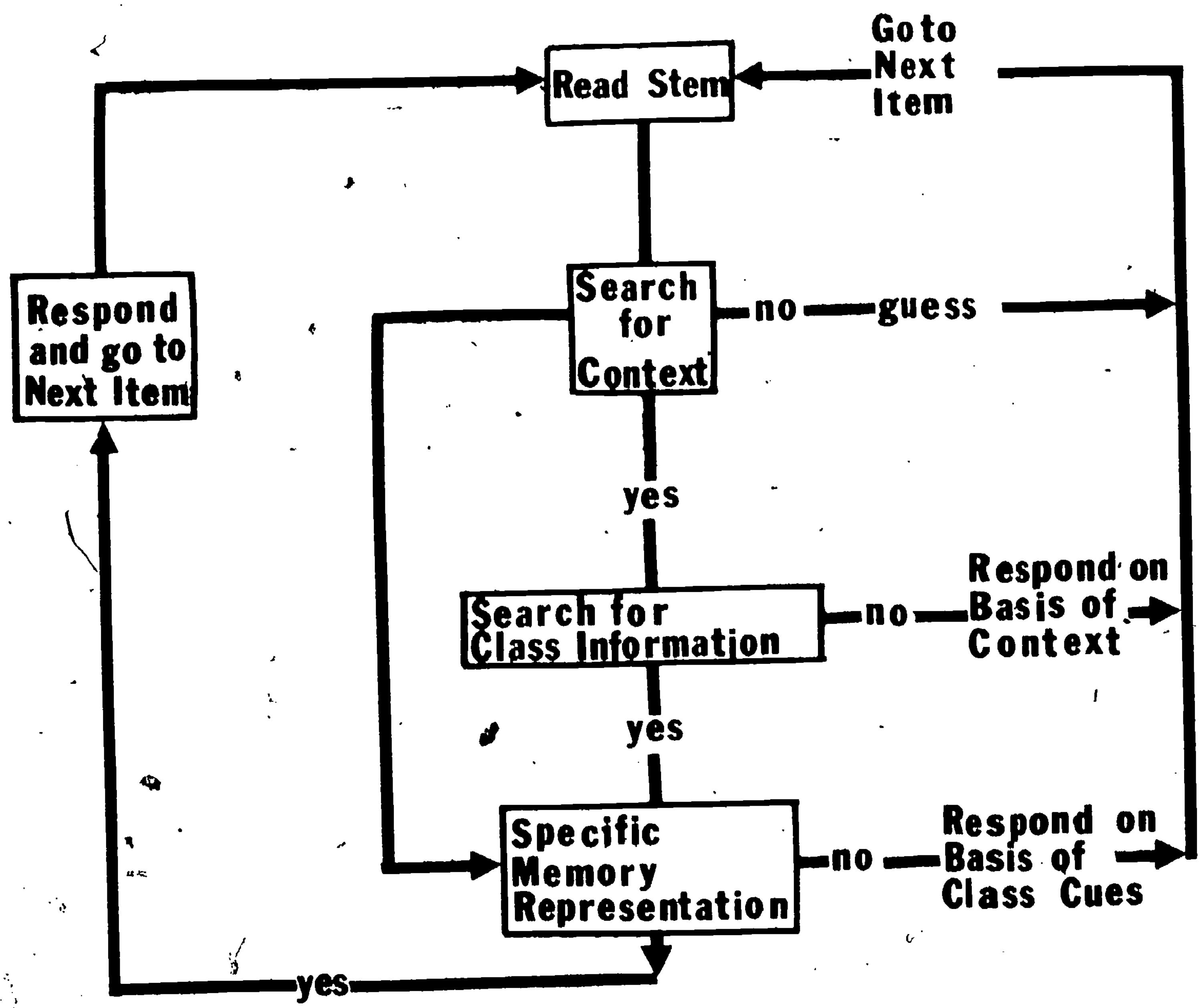
Go to Next Item
Read Stem
Respond and go to Next Item
Search for Context
no
guess
yes
Search for Class Information
no
Respond on Basis of Context
yes
Specific Memory Representation
no
Respond on Basis of Class Cues
yes